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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

COEN T.H.F. LIEDENBAUM

Serial No.

Filed: CONCURRENTLY

Title: DISPLAY DEVICE

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Commissioner for Patents
Washington, D.C. 20231

AUTHORIZATION PURSUANT TO 37 CFR §1.136(a)(3)
AND TO CHARGE DEPOSIT ACCOUNT

Sir:

The Commissioner is hereby requested and authorized to treat any concurrent or future reply in this application requiring a petition for extension of time for its timely submission, as incorporating a petition for extension of time for the appropriate length of time.

Please charge any additional fees which may now or in the future be required in this application, including extension of time fees, but excluding the issue fee unless explicitly requested to do so, and credit any overpayment, to Deposit Account No. 14-1270.

Respectfully submitted,

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Bescheinigung | Certificate | Attestation

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The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

00203895.8

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Demandeur(s):
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Titre de l'invention:
Display device

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Display device

The invention relates to a display device having pixel elements, and to a display apparatus comprising such a display device.

Display devices such as Cathode Ray Tubes (CRTs), Liquid Crystal Displays (LCDs), etc. are well-known. Each type of display has its specific advantages but also its specific disadvantages. For example, CRTs are quite bulky and consume relatively much energy, whereas LCDs have a limited viewing angle and brightness.

It is an aim of the invention to provide a display device that mitigates the above mentioned disadvantages. To this end the invention provides a display device as defined by claim 1. In this way a display device is provided that has a good viewing angle and good brightness while combining a low power consumption and limited display size.

Advantageous embodiments are defined by the dependent claims.

These and other aspects of the invention will be elucidated with reference to the embodiments described hereinafter.

In the drawings,

Fig. 1 shows schematically an embodiment of a display apparatus comprising a display device according to the invention;

Fig. 2 shows experimental results concerning a polymer that can be used in a display device according to the invention; and

Fig. 3 shows another embodiment of a display device according to the invention.

In general like reference numerals identify like elements.

Fig. 1 shows schematically the display device 1 according to the invention. A substrate 3 is provided with a stack of layers including a layer 5 of transparent electrode material of, e.g. Indium Tin Oxide (ITO), a thin layer 7 of fluorescent material, e.g.

fluorescent polymer, a dye or an inorganic compound like a phosphor, and a layer 9 that forms a back electrode. A source for generating electromagnetic radiation, here for example a UV source 11 is used to induce excitations, so-called excitons, in the layer 7 of fluorescent material. The source can be comprised in the device, but may also be an external source such as e.g. the sun. Such excitons may also be induced by the application of an electric field. These excitations normally will decay within their characteristic time to the lowest energy state, i.e. the ground state, of the polymer. In doing so light, in the figure indicated with arrows L, is emitted having a wavelength corresponding to an energy difference between an excited state and the ground state. Experimentally it has been observed that if a relatively large electric field is applied to the excitons, the excitons will dissociate into pairs of an electron and a hole (in case of polymers) and will not decay radiatively. This quenching or inhibition of the normal decay of excitons can be used to modulate light and a display device can advantageously be based on it. A display apparatus is provided if a display signal S, e.g. a conventional television signal, is used as input signal for a device 13, which converts the video signal into a modulating voltage that is applied to the electrodes 5,9. The light source 11 is controlled and modulated in relation to the modulating voltage by means of device 15.

Fig. 2 shows experimental results the light output of a 50 nm thick layer of a yellow emissive conjugated polymer (a Poly Phenylene Vinylene (PPV) derivative) as a function of the applied electrical field, when this layer is optically excited. It is shown that the intensity I of the emitted light is reduced, when the strength V of the applied electrical field is increased (here expressed in Mega Volts/meter). Above a certain value of the electrical field the light output is almost reduced to zero. This experiment has been repeated for different layer thicknesses of the fluorescent material, varying between 20 to 90 nm, and different types of fluorescent materials. The outcome of the experiments was always the same: the intensity of the emitted light is reduced when the strength of the electrical field is increased and above a certain field strength the light output is almost reduced to zero (quenched). A low value of the layer thickness, e.g. 25 nm is preferable in view of a consequent reduction of driving voltage.

Since the luminescence can be substantially quenched and the slope of the curves is quite moderate, the effect is suited for use in displays. By modulation of the amplitude or a pulse width of the applied field grey scales can be readily induced. If

fluorescent materials are used that emit light at different wavelength, a device emitting at different colors can be created. Such materials can be applied to the substrate with, e.g. printing techniques.

A display device having pixels is created e.g. if the electrode layers (5,9) are structured as a matrix, i.e. one electrode layer comprising rows and the other electrode layer comprising columns. Also the display device may comprise pixels in the form of segments that are individually addressable.

In case of graphic displays, which are suitable for displaying a high information content, active matrix driving may be a preferred method. Such active matrix addressing is known, for example from Thin Film Transistor LCD displays. Each pixel is addressed by one transistor and a hold capacitor. The electrical field over the fluorescent layer then is the parameter that is modulated.

The features of such a display device are as follows:

- no viewing angle dependence (fluorescent radiation follows a lambertian distribution curve)
- all colors are possible (at present many fluorescent materials emitting light in a huge range of various colors are available)
- high resolution (the resolution is determined by the pitch of the electrodes, which can be very small when photolithgraphic processes are used)
- fast response speeds (the effect is instantaneous)
- low power (in principle no current flows, high efficiency lamps are applied)

Fig. 3 shows an advantageous embodiment of the display device according to the invention. On a transparent substrate 3 a stack comprising a layer 5 of transparent electrode material, e.g. ITO or PEDOT (a transparent conductive polymer), a layer 7 of fluorescent material and a further layer 9 that forms the back electrode. The transparent substrate 3 is irradiated from a side by a source 11 for generating electromagnetic radiation, e.g. a blue emitting Light Emitting Device (LED). Due to internal reflection within the substrate the blue light from the LED irradiates the layer 7 of fluorescent material. If an appropriate electrical field is applied to the electrode layers 5, 9 the emitted light can be modulated and a picture is displayed.

In summary the invention relates to a display device 1 having pixels elements comprising a luminescent material 7 for emitting light when excited by, e.g. electromagnetic

radiation. The pixel elements are provided with electrodes 5,9 that modulate an emission of light by the luminescent material 7 by applying an electrical field.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. A display device (1) having pixel elements comprising a luminescent material (7) for emitting light when excited by excitation means, each of said pixel elements being provided with modulating means (5,9) for modulating an emission of light by the luminescent material.

2. A display device (1) according to claim 1, wherein the excitation means comprise means (11) for generating electromagnetic radiation.

3. A display device (1) according to claim 2, wherein the means (11) for generating electromagnetic radiation are comprised in the display device.

4. A display device (1) according to claim 1, wherein the excitation means comprise means for generating an electric field.

5. A display device (1) according to claim 1, wherein the modulating means (5,9) comprise means for applying an electric field on said luminescent material (7).

6. A display device (1) according to claim 4, wherein the pixel elements further comprise electrodes (5,9) that are provided to the luminescent material (7), the electrical field being generated by applying a voltage on the electrodes (5,9).

7. A display device (1) according to claim 6, wherein at least one of the electrodes (5,9) comprises a transparent material.

8. A display device according to claim 1, wherein a thickness of a layer of the luminescent material (7) ranges between 10 and 100 nm.

9. A display (1) device according to claim 5, wherein an electric field strength of the electric field varies between zero and 400 MV/m.

10. A display apparatus, comprising:

a display device (1) as claimed in claim 1;

means (15) for controlling said excitation means (11); and

means (13) for controlling said modulating means (5,9) in response to a display signal (S) applied to the display apparatus (1).

24.10.2000

ABSTRACT:

The invention relates to a display device (1) having pixel elements comprising a luminescent material (7) for emitting light when excited by, e.g. electromagnetic radiation. The pixel elements are provided with electrodes (5,9) that modulate an emission of light by the luminescent material (7) by applying an electrical field.

Fig. 3

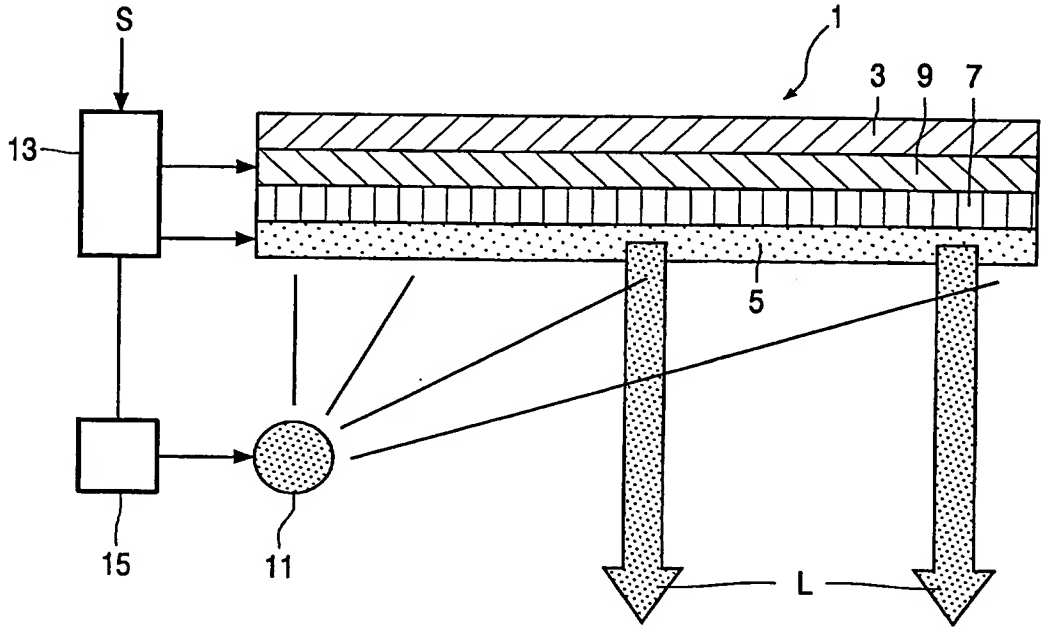

FIG. 1

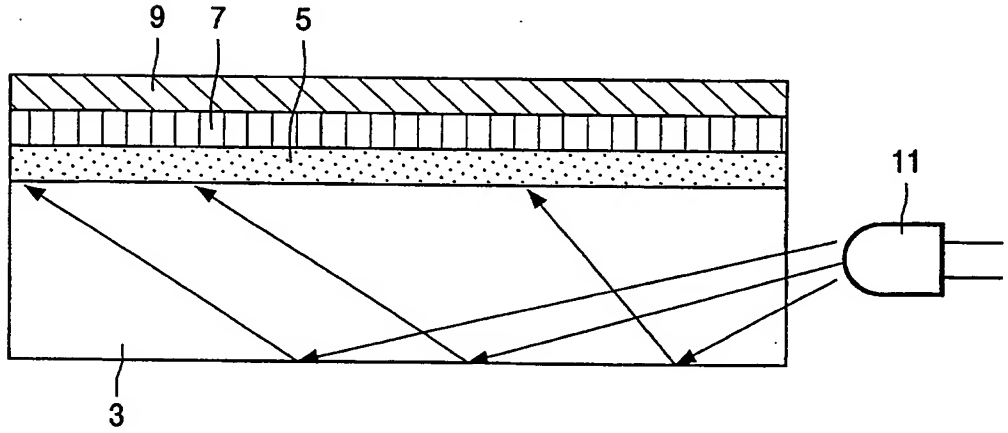

FIG. 3

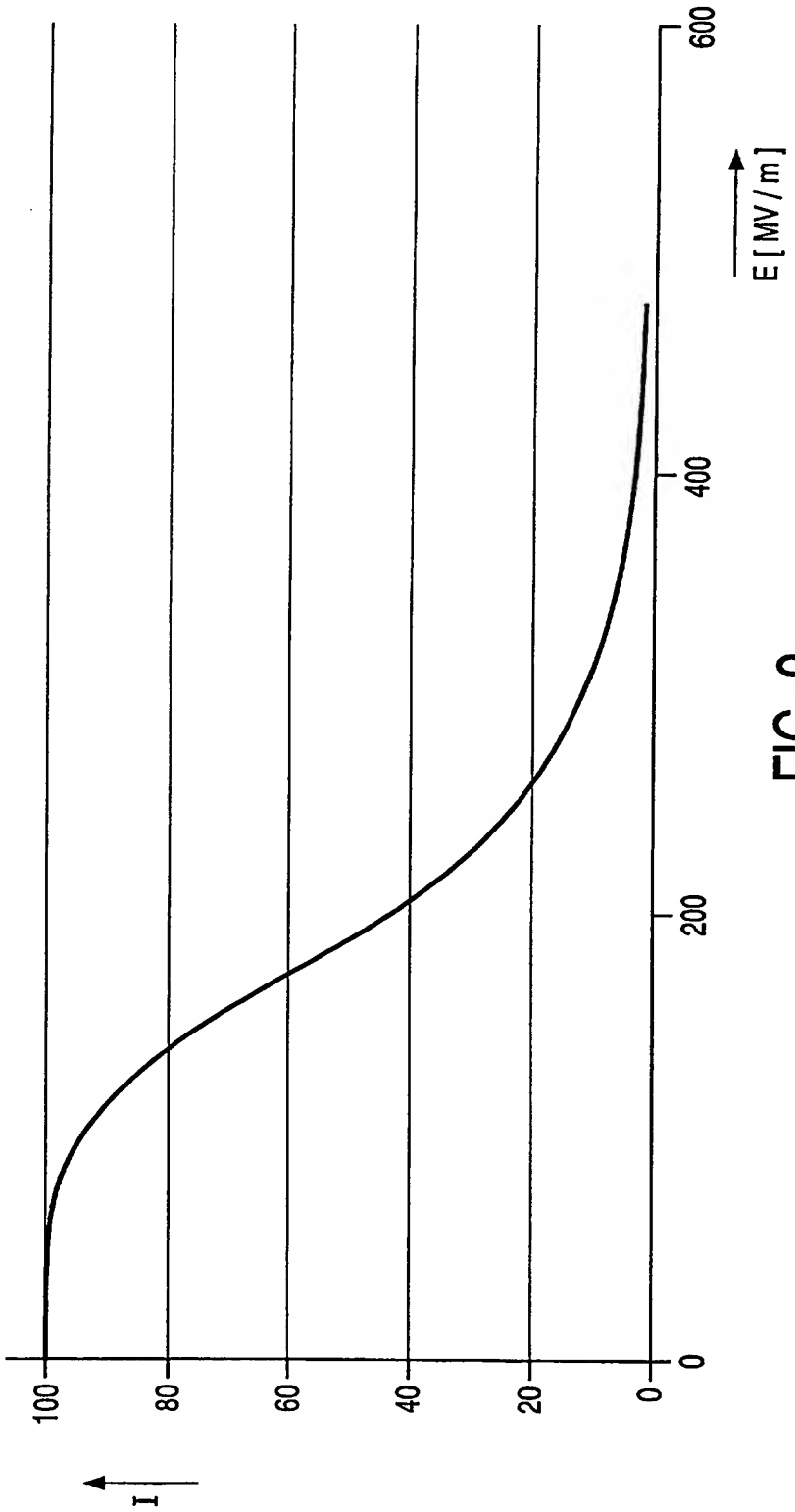

FIG. 2